Short Courses in System-on-a-Chip (SoC) Design

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I. Introduction

A contract between the Pittsburgh Digital Greenhouse and The University of Pittsburgh called for the development of a set of three (3) continuing education courses. The original objectives, anticipated student background, and schedule of each course are briefly described in the rest of this section.

The first developed course in the three-course sequence is an *SoC Overview* course. This overview course was projected to have a length of one to two days and was targeted at a broader SoC design audience without strong integrated circuits (IC) design background. Typical attendees of this course include system, hardware, and software engineers, as well as engineering and general managers with limited technical background. The primary objective was to provide a basic understanding of the SoC design process, of the associated benefits and risks, and of other management, business and non-technical issues.

The next two courses are named *System Level SoC Design* and *Structural Level SoC Design*. These courses are targeted towards design engineers and first level managers with either board or IC design experience, and who want to transition to the design of SoC's. These courses focused on different aspects of the SoC design process and were designed to be deliverable in a stand-alone fashion. However, attendees to these two courses were encouraged to attend an SoC Overview course first.

The System and Structural level courses are intended as four or five-day-long. These increased course lengths are due to the inclusion of laboratory exercises where the students participate in guided SoC designs. Commercial CAD tools are employed in the laboratory sections and—since the majority of the students are unfamiliar with the CAD packages—these laboratory exercises are designed in a CAD tool tutorial manner. In other words, proper CAD tool use was additionally emphasized in the laboratory exercises.

II. Experience

The first version of the SoC Overview course was offered in a one-and-a-half-day-long format. The profile of the audience was close what the course was designed for. A portion of the class had substantial technical design expertise and contributed valuable comments towards improvement of both the course content and presentation. It was unanimously decided that the course length must be decreased, especially in view of the lack of laboratory work. For the second and subsequent offerings, the SoC Overview course was reduced in length to one single day.

For both the System Level and Structural Level SoC Design courses, the class compositions did not meet the original course design guidelines. In a continuing education environment, it is necessary to have sufficient flexibility in the course design to permit students with various strengths and weaknesses equal participation. Design experience was scarce, and experience with programming languages such as VHDL and C++ was generally lacking. However, the tutorial material on VHDL, the commercial (Mentor Graphics HDL designer) software tutorials, and the use of design teams, made up for the lack of skills in individual students. Certain students had real-world expertise in various aspects of IC design which complemented the instructors. Flexibility in the delivery and schedule permitted capitalizing on these student knowledge and enhancing the overall courses experience.

A detailed outline and course syllabus are required for providing structure to both the System and Structural level courses. In addition, flexibility in the delivery of the material and laboratories is essential to the success of these courses. In the first offering, for example, the Structural course was given after the System level course. Both courses ran the full four and a half days and the majority of the students were in all three courses (including the SoC Overview course). In the second offering, the Structural course ran before the System level course and ran three days with abbreviated laboratories. The second group of students had not taken the SoC Overview course at all.

While both offerings were successful, each offerings satisfied different student needs. In the second offering—with limited exposure to the laboratory exercises—the students developed a stronger appreciation of the SoC issues rather than developing a strong SoC design experience. Nevertheless, the students felt that they received the training they expected. This and the time commitment of the one-week-long course raise the question of the audience and timing for future offerings.

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Having an advanced copy of the course material before the lectures were presented provided the students with a second modality to the course delivery. Students followed along in the notes, anticipated topics and were willing to actively participate in lectures. Providing copies of suggested book readings [1–3] proved useful for the students—the students read the books in the evenings and were better prepared for the upcoming lecture material.

The integration of lectures and laboratories into a unified flow provided highly beneficial aspects of each course delivery. Not only was a third modality—reading, hearing and doing—for learning provided, but students were able to absorb close to 1,000 lecture and laboratory presentation slides. The availability of two lecturers with different styles was also helpful. The punctuation of frequent breaks, multiple lecturers (including the Teaching Assistants for some laboratories) and hands on laboratories kept the students attentive and engaged throughout four and a half long days.

Keeping the lectures interesting was a challenge. What worked best was keeping the students engaged in a dynamic dialogue. This approach worked well in the small class/lab room environment. Leveraging off the students own design experience was also important. Since the class mix included managers as well as designers, lively debate often occurred.

It should be noted that the material is timely, in both the positive and negative sense. Design houses are transitioning to designing SoC's using the methodologies taught in the described courses. In a few years, however, these methodologies may be out of date. It is likely that platform-based design with vertical partnering of intellectual property (IP) providers and silicon vendors will dominate the market. While much of the material on design practice will remain valid, the design methodology and flows may easily become outdated. The inclusion of the laboratory component of the courses was essential in making the System Level and Structural Level courses true immersions into SoC design. Without the laboratories, the courses may quickly devolve into 'SoC Appreciation' courses.

It must be noted that the preparation of the laboratory exercises was significantly more time intensive than the preparation of the lectures. The laboratory exercises for the courses must support the lecture material as well as lead the students through the designs. Therefore, the right set of exercises needed to answer to the following set of requirements: *(i),* blend well with the lecture material, *(ii),* incrementally follow the design flow at the system level for a single, relevant piece of intellectual property, *(iii),* use a minimal set of tools with short learning cycles, *(iv),* provide a design experience with minimum frustration and lost time, *(v),* result in an incremental step towards a complete system or IP block, which can be used in the next laboratory, and *(vi),* complete with a finished system level design or an IP block that can be used in the System Level course. Note that the last three requirements are nearly mutually exclusive. Hence, a less specific approach was adopted in a number of laboratory exercises. The students were given the parameters of the exercise, including step-by-step instructions and a deadline. However, a 'finished-from-the-oven' problem solution was also provided for use in the following laboratory.

III. Conclusions

The two most important issues for the future are first, the timeliness of the described SoC material and second, the length of the course offerings for the laboratory intensive courses. Both questions are relevant for future offerings of the courses.

The material must be continuously updated based on current best practices for SoC design. This update process must involve more than just gathering material from textbooks since textbooks are frequently out of date (and/or written to favor a particular commercial vendor).

The amount of presented material was large and sufficient to fill a typical semester-long academic course. Such quantity of material is difficult to absorb in one continuous week (it is also difficult for full-time employees to dedicate an entire week to the class). Note that offering the course as a 'one night a week' course has both advantages and disadvantages. Consider the software/hardware CAD infrastructure, for example. This infrastructure must be set up and maintained for the length of the course with access to the software by all the students between class meetings. Or, consider the the inevitable loss of focus factor that stems from only thinking about the material once a week, after a full day of work. Other issues include the lack of integration of the lecture and laboratory material, hence relying on the students to complete the labs on their own. While permitting more time for the completion of assignments, the latter approach may break up the team project aspects of the experience. One of the best options may be breaking the courses into two-day-long or three-day-long segments while keeping the laboratory exercises intact.

Perhaps the most overriding issue, however, is who must be the target audience. The consideration of this issue must set the context for the future course offerings. If the audience is primarily managerial, then the labs are not essential. Nor are the laboratory exercises required for experienced designers who can understand new design flows without much hands-on work. If, on the other hand, the audience consists of mostly new designers or engineers (lacking significant background in digital design), then the laboratories are an essential component of the course and must be maintained.

References

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